

Active and Experiential Learning at Olin College: Opportunities and Challenges

by

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Executive Summary. The innovative undergraduate engineering curriculum under development at Olin College makes extensive use of active and experiential learning methods. These include team projects, independent study, research, and entrepreneurial activity. While many other engineering schools use these methods to some degree, the curriculum proposed at Olin College uses them much more extensively. For example, it is relatively common for a B.S. degree in engineering to require 32-40 semester courses over four years, of which 2-3 required courses involve a team or design project. The current Olin College curriculum proposes a significant project course in all 8 semesters, resulting in a commitment that is 3-4 times that of most other schools. While the benefits of active or experiential learning are believed to be substantial, so are the costs. The purpose of this paper is to explain in some detail these benefits and costs, and to request advice and guidance from the reader. It is important for strategic planning purposes to decide now whether to adjust our financial plan and priorities to accommodate the anticipated added costs of a high level of commitment to active learning, or to reduce our level of commitment to the active learning approach instead.

Goals and Objectives. Olin College's mission is to provide an education that will prepare its graduates to "*predict, create and manage the technologies that will shape the future.*" Few disciplines are as fast moving as engineering, since the advances of new technologies are relentless and accelerating. As a result, the expansion of the technical material in all engineering disciplines in the last two decades has been explosive. Most engineering educators now agree that it is no longer feasible to provide every student with a meaningful exposure to all the technologies he or she is likely to need during a 40+-year career in engineering. Instead, the emphasis has shifted away from a curriculum with an ever-expanding content to one based on teaching the fundamentals with a focus on *learning how to learn* and building the expectation for life-long learning. We at Olin College firmly believe that the most successful engineers in the next generation will be those that are agile learners able to identify important new developments and independently learn the essential details of these new ideas while incorporating them into their professional career. Learning how to learn in various ways and in different environments is therefore an important goal of our educational approach.

Thus, independent study, research, and team project work must become very important modes of learning in our emerging curriculum. For our educational approach to be effective, our graduates must be better at independent learning than those of any previous generation. They must be comfortable in approaching a technical problem based on technologies with which they are not familiar. They must have sufficient foundation in the fundamentals of mathematics and science that they are capable of understanding these new technologies, and they must have enough confidence in their ability to learn independently that they will not hesitate to attack such problems, no matter how difficult they may seem. They must be able to independently identify the appropriate sources of information on a new topic, and to penetrate the literature pertaining to its development. They must be able to formulate the key questions, understand the fundamental experiments that define the essence of the new technology, and envision the impact of this technology on their professional career. They must know how to determine the validity of sources of information and how to identify accurate and reliable consultants. They must know how to make the best use of the expertise of team members with very different backgrounds when approaching a new technical challenge. They must know when to stop reading and when they know enough about the subject to independently reach valid conclusions and to apply their new knowledge. All of these aspects of independent learning—and many others—must be cultivated and nurtured if the mission is to be fully achieved.

In order for students to become effective independent learners, they need to experience this mode of learning throughout the curriculum. While many engineering colleges today provide opportunities in the senior year for team projects or individual study with a faculty member, the approach at Olin College is based on beginning the exposure to independent learning and group study much earlier in the curriculum. Based on the many successful experiments conducted last year during the Olin Partner Year, we believe that students of the caliber we have attracted are capable of far more extensive projects in independent learning than are common on other engineering college campuses. We also believe that this “expeditionary learning” approach enhances the depth of understanding and the retention of material. Therefore, we have designed a curriculum at Olin College that includes independent study or project-based learning throughout the program.

Olin College’s mission challenges us to not only provide an educational experience that will prepare graduates to predict and create the new technologies, but also to manage them. Not every new technical idea has the potential for making an important impact. In order for our graduates to achieve this goal, they will need to know how to recognize business opportunities linked to new technologies. In addition, they will need to understand business basics—how to read a financial statement, what functions budgeting and accounting play in a business enterprise, the value of intellectual property, marketing, manufacturing, customer focus and management principles—in order to manage the technologies that will shape the future. Many practicing engineers believe that current engineering education over-emphasizes the importance of technical ability, and under-emphasizes the importance of communication skills, teamwork, and the basic principles of business. Through the continuous exposure in all 8 semesters to team projects supplemented with instruction in business principles and teamwork skills, we plan to provide better preparation for Olin graduates in this important area.

The Olin College curriculum addresses this aspect of our mission directly. Both courses and project experiences that involve commercialization of technology will be woven throughout the curriculum. Furthermore, Olin College students will be required to interact with business students at Babson College in various ways during their undergraduate years, ranging from taking courses side-by-side in the humanities and social sciences, to taking business courses and partnering together in selected projects involving entrepreneurial ventures. These projects will likely include some courses that involve students enrolled from both campuses, and some extra-curricular activities in which Olin students partner with Babson students in attempts to start new ventures. Both of these activities are already underway, and they are expected to grow substantially as the latter years of the curriculum are developed.

“Entrepreneurial thinking” plays a central role in the emerging Olin College curriculum. As one of three major themes in our educational approach, we believe that every graduate of Olin College should understand the process of commercialization of technical ideas, both within a major corporate environment and in a start-up enterprise. Understanding this process requires exposure to intellectual property and patent law, opportunity recognition, product design and development, new venture creation (including development of a business plan, estimating costs, scheduling concerns, etc.), capital generation, manufacturing, marketing and managing of a new enterprise. Since entrepreneurial activity is equally important within major corporations, these principles will be taught in a way that provides the necessary skills for success in the corporate environment as well as in a start-up enterprise. Graduates who are successful at managing the technologies that will shape the future must understand at least these basic issues.

Our location adjacent to Babson College enables us to provide academic programming in this area that is unique and effective. It also challenges us to provide a learning environment that matches the highly entrepreneurial approach at Babson College. Babson is one of the most innovative and entrepreneurial colleges in the nation, having won the 2002 Hesburgh Award from TIAA-CREF and the American Council on Education for the most innovative undergraduate program in all of U.S. higher education. In addition, Babson College has consistently been

ranked first in the nation in national polls for its entrepreneurship educational programs. Its internal policies and procedures, as well as its faculty and student culture, are more supportive of entrepreneurial activity than those at most other business or engineering schools. In order for Olin College to maximize its potential in this area, it needs to establish a campus culture that embraces these best practices at Babson College and ingrain them deeply into our programs and culture.

Perhaps the best way to learn entrepreneurial thinking is also through team projects and experiential learning. The benefits of learning by personal experience from starting a new venture and managing it are compelling. Babson College already requires all of its freshmen to participate in the year-long formation and operation of a new venture—and their results have been exceptional. Students not only obtain a well-grounded understanding of the role of each organizational function in a business, but they also finish the year with a high degree of enthusiasm and a strong commitment to completion of the program. We envision team projects at Olin College that will involve students from Babson and Olin working together on new ventures with similar results.

Student Quality. The curriculum we have designed presumes that the student body we attract will be very well prepared and eager to learn. Independent learning requires a high degree of maturity and intellectual independence, as well as a degree of self-confidence and ambition that are exceptional. It takes rare intelligence and tenacity to tackle and succeed on independent study projects without the benefit of much formal background. In addition, successful teamwork requires a degree of maturity and ability to communicate and work with others that is not common in the national population of engineering students. In short, the curriculum we have designed demands an exceptional student body.

However, the caliber of students we have already attracted is indeed exceptional. By all conventional measures, the level of intelligence and academic ability of the students at Olin College is among the highest in the nation. As reported in our recent publication on the profile of the class of 2006 (our inaugural class), the middle 50-percentile band of the combined SAT scores of our 75 students is 1440-1530. The average GPA of this class is 4.3/4.0, and 41 of the 75 have been recognized by the Advanced Placement program. Twenty-nine of the 75 students in this class are National Merit Scholarship Program Finalists, and 3 are recipients of U.S. Presidential Scholarships. Twenty were valedictorians of their high school class, and 9 were salutatorians. Seventeen were captains of academic teams in high school, and 11 were captains of athletic teams. Nearly all of these students chose Olin College as their first choice college, and a large number of them turned down admission and scholarship offers from many of the nation's best known universities (MIT, Caltech, Stanford, Cal Berkeley, Harvard, Michigan, etc.).

Based on our experience last year with 30 of these students in the Olin Partner Program, we believe that they are capable of excelling in the program we are developing. In fact, we believe that these students expect and need a program that provides extensive opportunities for teamwork, independent study, and research, and without such opportunities they are likely to become disappointed. Students of this caliber expect and deserve the opportunity to become personally involved in project work and independent study.

Faculty Quality and Motivation. Faculty members play the central role in developing, delivering, and guiding the educational experience at every excellent college or university. Like all teachers, they can only teach what they know, and whether they realize it or not, they teach more by personal example than by exhortation. In order for faculty members at Olin College to succeed in providing an educational program rich with team projects and independent learning, the faculty members themselves must be expected to model this behavior. Faculty members must be effective at demonstrating teamwork among themselves in order for students to realize the benefits of this approach and to become skillful at it. In addition, faculty members must be

committed to a lifetime of independent learning in their field, and they must demonstrate this commitment to their students. Faculty members at Olin College are first expected to be or become inspirational teachers of undergraduates. However, they are also expected to demonstrate nationally visible achievement in their field. The faculty members we have sought and attracted are committed to continuing their professional competence while modeling the professional activity and achievement that we expect our students to attain.

The learning environment we have begun to build at Olin College will depend in large part on the success of our faculty members in developing a significant number and breadth of projects, research and independent learning opportunities for our students. Every faculty member at Olin College is committed to involving undergraduate students in his or her professional work. In fact, one of the selection criteria used in deciding which faculty members to hire was a deliberate assessment of the potential for the involvement of undergraduate students in their research and scholarship.

Although Olin College is an undergraduate institution, it is not a teaching-only institution. From the start we have been determined to attract faculty who are committed to continuing professional development of the highest caliber, including published scholarship and funded research as well as other activities. The fast moving pace of engineering requires that teachers remain engaged in the creation of new knowledge or inventions or commercialization activities to stay abreast of current developments. All of our faculty members have exceptional achievements or potential for such achievement in research and scholarship, to a level that is unusual for an undergraduate institution. In fact, all faculty members are expected to pursue nationally visible achievement in their field, and to devote a significant fraction of their time to maintaining their own intellectual vitality.

The quality of our current faculty is exceptional by all standard measures. Of the 18 regular faculty members currently employed at Olin College, 3 were recruited from tenure-track faculty ranks at MIT. Most of those with teaching experience have been recognized for teaching excellence by other colleges and universities. Those without significant prior teaching experience have both exceptional achievements and a conspicuous passion for teaching. Among our faculty are a concert pianist who has performed solo at Carnegie Hall in New York; a former Director of Space Sciences at NASA Goddard; a Rhodes Scholar; the former head of the math department at Harvey Mudd College; a well known geneticist and former professor of medicine. All of our faculty are graduates of the nation's best known research universities, and all share a passion for teaching undergraduates.

The importance of the involvement of engineering faculty in creating new technology and scholarship in order to stay abreast of new developments is so well established in engineering colleges across the U.S. that nearly all such colleges include Ph.D. programs and are located within major research universities. The mission to provide advanced graduate education at major research universities assures that faculty members are deeply engaged in the creation of new knowledge in their field. Undergraduate colleges that offer a degree in engineering comprise a small minority of institutions. Those undergraduate institutions committed to offering an engineering degree are at a disadvantage in this regard. As a result, the success of Olin College in attracting faculty members with substantial abilities and achievements in research as a secondary activity is remarkable and quite unusual.

The early success of Olin College in developing major externally-funded research programs is noteworthy, and is an indication of the potential for the College to grow and sustain the high level of independent study and research opportunities anticipated in our curriculum. One common measure of research activity within an engineering college is the level of externally-funded

research.¹ This is research activity aimed at creating new knowledge that is paid for either by a grant or contract from a third party—often the federal government—and usually involving some form of competition for funds (often a peer review of research proposals). Comparisons of the relative success of different colleges in attracting such external research funding has become a surrogate metric for the quality and relevance of the research of the faculty members. (This metric plays an important role in the public media ranking of the quality of engineering Ph.D. programs by U.S. News & World Report and other publications.)

Although Olin College launched its first academic courses only a few weeks ago, it has already established a very respectable externally-funded research program. Shown below in Table 1 are results for the most conservative measure of research activity at Olin College—actual expenditures of research funds (not total grant awards received)—for each fiscal year the College has employed faculty members.

TABLE 1
Research Expenditures at Olin College for FY01, FY02, and FY03

Fiscal Year	Approx. No. Faculty	Total Expenditures
2001	10	\$351,104
2002	15	\$1,016,452
2003	18	\$1,300,000 (est.)

This level of research funding is quite high for a small undergraduate institution. Using comparative data for research expenditures at comparable high quality undergraduate engineering colleges for FY01 (the most recent year available) our research expenditures greatly exceeded that of several excellent schools on a per-faculty-member basis. The level of funded work per-faculty-member expanded considerably in FY02, presumably increasing our lead in this area. The point is that Olin College has quickly established a record of funded research activity that is truly unusual for an undergraduate institution.

If we continue on the current trajectory, Olin College will establish an average research expenditure rate of nearly \$100,000/year/faculty member. This is much higher than the average for even high quality undergraduate institutions, and is approaching the lower levels for major research universities.

Resource Implications. Olin College has begun developing and implementing a demanding new model for engineering undergraduate education. The level of independent study, research, and team project work involved in the new curriculum appears considerably larger than that at other engineering schools. In addition, the commitment to learning the process of commercialization of technology through entrepreneurship is also considerably larger than that at other schools. The quality of students in our inaugural class is adequate to benefit from this approach, and the quality of the faculty we have attracted is adequate to provide the level of research and entrepreneurship opportunities needed to initiate the program. To take maximum advantage of this opportunity likely will require incrementally more teaching resources on a per-student basis than other engineering schools require. We are not yet certain at this early stage, but we feel this is likely in spite of our efforts to increase efficiency over the next few years.

The required resources include increased access to faculty and staff, laboratory and shop resources, library and computer resources, and opportunities to explore the commercial implications of new inventions. If students are expected to succeed at important engineering challenges, they need access to state-of-the-art technology in laboratories and shops. It is

¹ Externally-funded research does not include research funded by internal College sources, nor does it include external funding for student projects. (Student projects are aimed primarily at providing educational experiences rather than creating new knowledge.)

difficult to over emphasize the value of the hands-on experience of building a professional-quality working prototype of a new invention, in contrast to the development of only a rough proof-of-concept model. The additional learning associated with exposure to precision fabrication and advanced materials used in a professional quality prototype is fundamental to the educational advantage that is possible with the current project-based curriculum at Olin College. This requires both space and time for students to work with their hands to do the bulk of the fabrication themselves in a safe environment, and to save their work-in-progress in an appropriate space. Abundant access to both modern equipment and highly skilled lab technicians is of central importance to supporting this curricular thrust.

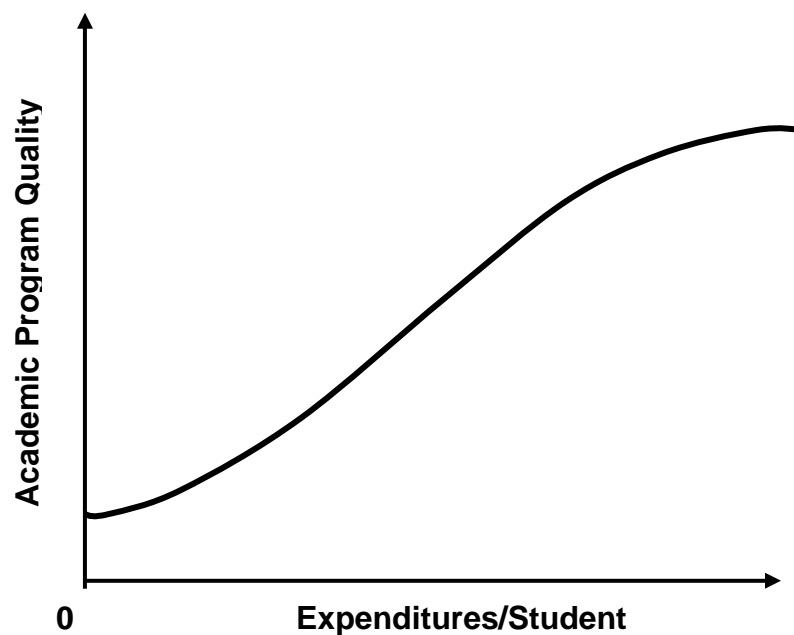
If Olin College delivers a program with 2-3 times as much project-based education as other schools, and if these projects require the fabrication of prototypes and devices, then the shop and lab resources required to support such a program will be significantly larger on a per-student basis than those at other engineering schools.

Independent study and research projects that do not necessarily require students to build prototypes place other demands on resources. These include the need for substantial amounts of faculty time for one-on-one coaching and advising. In addition, first-rate library and computer resources are required to enable students to find and utilize learning resources on their own. It is precisely this experience of *learning how to learn* that we are attempting to foster in our curriculum. While all engineering programs allocate faculty time for advising and provide access to libraries and advanced computer resources, the experiential learning nature of the current Olin College curriculum is likely to place greater demands on these resources than programs at other colleges. It is impossible to know at this early stage how much greater these demands are likely to be, but the amount of faculty time spent outside the classroom in coaching independent projects is likely to be substantial. The consequences are that more faculty members will be required to deliver the courses and supervise the projects.

We have embraced the mission of preparing leaders capable of managing the technologies of the future. Our curriculum weaves exposure to the fundamentals of business and entrepreneurship throughout all four years, and provides exposure to start-up ventures in concert with Babson College. The linkage with Babson College in this area provides a unique opportunity to develop an engineering education rich with teamwork experiences with business students and with personal experience in the commercialization process. While many other engineering colleges are located on a large university campus with both an engineering college and a business college, the independent cultures of these two professional schools have proven challenging to link together. By starting from a clean slate with enthusiastic support from the faculty at Babson College, we have the opportunity to build a truly integrated program in this area that few existing schools can match. In order to maximize this opportunity, we must create an environment where entrepreneurial activity is encouraged and supported in visible ways. Babson College already has established a remarkably entrepreneurial culture. To become a partner in this activity, Olin College will need to develop a culture that is equivalent in its support of entrepreneurial activity among both students and faculty members. This will require embracing policies and procedures relating to intellectual property and new ventures that are forward looking and supportive to all involved in these activities in order to provide the proper incentives and rewards. If we fail to do so, we may have less opportunity to form the necessary linkages between engineering and business than schools co-located on a single large university campus.

Many factors are involved in determining the overall quality of an educational experience provided by an undergraduate college. One of the most obvious factors is the amount of money spent each year in direct support of the undergraduate educational experience. This money is spent largely for salaries, but also includes facilities-related costs, materials and supplies, library acquisitions, etc. Within a certain range, the quality of the educational experience can be assumed to increase with increases in these expenditures, as shown in the figure below. This assumes that the increased expenditures are all directly related to enhancements in the

academic program (more teaching faculty members, more lab technicians, more library resources, etc.).



Olin College's financial model is based on a formula-driven income provided by the earnings of a large endowment from the F.W. Olin Foundation. It is assumed that this income will be supplemented by significant but unpredictable support from corporations, other foundations, and individuals. However, tuition revenue is not currently included in our financial model (except for a small amount provided by external scholarships earned by our students). We are therefore assuming that the amount of annual operating funds available in any year is largely independent of the number of students enrolled. Thus, the basic overall strategic planning decision we face is one of determining how to use the fixed amount of funding we will have in any year.

In these early years, we face two distinct tasks: (1) develop and test an innovative engineering curriculum, and (2) deliver that curriculum to a small group of students. Each of these tasks involves certain inherent expenses. When we complete the start-up activities and settle into a steady-state mode of operations, our efforts will be largely devoted to delivering the curriculum. To estimate the costs associated with this eventual steady-state operation, it is necessary to estimate the total enrollment that the College can support with its limited resources. The basic question is then how many students can Olin College afford to educate on its endowment-driven annual income?

The basic trade-off in determining this maximum enrollment is one of quality vs. quantity. The early planning model for Olin College assumed a 10:1 student/faculty ratio, and annual expenses similar to those at comparable undergraduate engineering schools. This led to an estimated total enrollment of 650 students, and a total faculty size of 65. Equivalently, the model is based on a target for total annual expenditures per student of about \$50,000 (in current dollars).

As noted in the previous discussion, the exciting new curriculum that we are developing may cost significantly more to deliver than that at other engineering schools. Thus, the annual expenditures per student required to deliver the emerging curriculum at Olin College may exceed the amount in our current financial model. Since the total available funds are fixed, this would result in a reduction in the total enrollment of the College when fully developed. Thus, there is a

direct relationship between the total enrollment Olin College may eventually support, and the quality of the program it provides—with associated program costs.

Setting Priorities and Planning for the Future. As Olin College begins the process of strategic planning this year, we face key questions relating to priorities and the role of active and experiential learning at Olin College. The new curriculum we have developed addresses all of the important objectives identified by the National Science Foundation and business leaders, but it is potentially more expensive to deliver than our current financial model has anticipated. Learning by discovery is more demanding of faculty time and college resources than the principal alternative—passive learning in the lecture mode. Achieving a reasonable balance between these two modes of learning is the goal.

As we begin the process of strategic planning this year, we will face the need to develop relative priorities which will determine the academic quality, expenditures-per-student, and the target for total enrollment. To help us in these considerations, we need to answer the following basic questions:

1. How important and valuable is our curricular emphasis on team project work, independent study, research, and entrepreneurial activity for the future of our graduates, in your opinion?
2. Should we consider reducing our target for total enrollment downward from 650 (or equivalently, increasing our expenditures-per-student) to insure the success of this curricular emphasis? If so, how far should we go in this direction?
3. Are there any aspects of our developing program in active and experiential learning that appear to be over-emphasized or under-emphasized, in your opinion?

Your comments on these questions are important to us, and will be given serious consideration as we enter our strategic planning exercise for this year.